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ABSTRACT

This two-part report reviews three major areas of influence in the mathematics learning of minority children: (1) learning style, personality and self-concept influences; (2) linguistic effects; and (3) school influences. Low mathematics achievement and nonparticipation of Black, Hispanic, and Native American children have become concerns of administrators, teachers, curriculum directors, and parents. As our society becomes increasingly more technological, the ramifications of this educational situation become more drastic. This paper reviews results of general studies on achievement of minority students and draws on research in mathematics achievement of the general population to locate the impact of certain factors on the minority pupil situation. Each of the three major factors identified are reviewed in detail, with the many interconnected factors discussed, and separate and combination affects assessed where possible. The report concludes with a summary and recommendations for changes in educational practices and suggestions for further research. The appendix contains a list of additional references on other factors relevant to mathematics learning of minority students. Part two of this report is an annotated bibliography of selected research studies in minority education. (MP)

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FINAL REPORT

STATE-OF-THE-ART REPORT ON MATHEMATICS ACHIEVEMENT OF SUTDENTS OF BLACK, HISPANIC, AND NATIVE AMERICAN ORIGINS

Contract #NIE-P-79-105

July, 1980

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INTRODUCTION

The mathematics achievement of Black, Hispanic and Native American children has become a concern of administrators, teachers, curriculum developers, and parents. The combination of low achievement and nonparticipation in advanced mathematics and science courses severely limits the career opportunities for these students. As our society becomes increasingly more technological, the ramifications of this educational situation become more drastic. Corporations and institutions who employ engineers, computer programmers and analysts, natural scientists, and mathematicians, all decry the shortage of qualified Black, Hispanic, and Native Americans.

A careful examination of the factors which have created the present situation in mathematics education should give concerned policy makers and practitioners ideas for future directions. This paper will consider three major areas of influence in the mathematics learning of minority children: learning style, personality and self-concept influences, linguistic effects, and school influences. Within each area, many interconnected factors will be discussed; separate and combination effects, where possible, will be assessed. Whereas the research on the education of minority children is plentiful, specific studies on the mathematics achievement of these children, especially in regards to particular ethnic groups, are more scarce. In some cases, inferences about mathematics have been drawn from general studies on achievement of minority students. Similarly, research on the mathematics achievement of the general population has been reviewed and, where appropriate, results have been

discussed in light of the minority student situation. As is true with every research appraisal, total agreement among investigators in the relationships between variables under study rarely exists. Nevertheless, enough evidence indicating the impact of certain factors on the achievement of minority students has been located. In addition, the needs for further research are addressed at the close of the report.

Before discussing the data and results of the literature review, a clear picture of the meaning of success in mathematics will give the readers a common perspective with which to proceed. To many, an excellent elementary school mathematics student is one who performs the basic operations (addition, subtraction, multiplication, division) on whole numbers with speed and accuracy; a junior high school student is often considered adept at mathematics if he/she extends his/her operational proficiency to fractions, decimals, and percents; on the high school level, the development of equation solving skills, mastery of polynomial operations, and some familiarity with theorems in Euclidean geometry would be taken as signs of successful achievement in mathematics. The abilities that are missing from these lists are those which are most applicable to the needs of our society today. No longer do we need human data banks; computers use far less time and energy than people to store and operate on numerical information. A truely successful mathematics student must have highly developed reasoning skills, spatial ability, and problem solving strategies. He/she should feel some control over the subject of mathematics and not merely be a blind receiver of seemingly unrelated concepts and rules. Mathematics is a creative discipline; students who really understand it know that. They delight

in expressing themselves through unique and elegant mathematics expressions. Excellent mathematics students know how to draw upon their vast resources to solve problems; they know how to break a problem down into parts and to find the kernel or essential questions to be answered. He/she can reconstruct a problem in a number of ways and not give up until a reasonable solution is reached. A fine elementary mathematics student can not only perform the algorithms for the basic operations, but also understands why these procedures work; he/she perceives patterns and relationships among numbers. An outstanding secondary mathematics student not only learns algebraic and geometric theorems, but is able to prove these theorems using fundamental axioms and properties of the system. He/she attacks complex work problems with confidence and determination. This perspective on what constitutes success in mathematics should give the readers a deeper understanding of the range of possibilities that exists in the mathematics classes of schools in the United States.

SECTION I. Data on Mathematics Achievement and Participation of Black, Hispanic, and Native Americans

The most recent comprehensive set of data on the mathematics achievement of Blacks and Hispanics was compiled in 1978 by the National Center for Educational Statistics with the results of the second mathematics assessment test performed by the National Assessment of Education Progress project. The test was divided into three categories. Knowledge and skills understanding and applications; it was mostly multiple choice, but also contained a few open-ended questions. For each category, the following table shows the percentage difference from the national norm for Blacks and Hispanics by age. A negative difference indicates below norm percentages, positive differences would denote above norm percentages.

Knowledge and Skills

	9-year-olds	13-year-olds	17-year-olds
Black	-10.8%	-16.8%	-17.6%
Hispanics	- 7.9%	-12.0%	-12.0%

Understanding

Blacks	-10.3%	-14.8%	-17.4%
Hispanics	- 8.2%	-11.8%	-13.8%

Applications

Blacks	-10.7%	-13.7%	-17.8%
Hispanics	- 8.2%	-10.5%	-12.1%

For example, thirteen-year-old Black students scored 16.8% lower than the national norm on the knowledge and skills section of the test.

Changes in mathematics achievement between the first and second assessments, 1973 to 1978, were reported by the N.A.E.P. in August, 1979. They found that, as a nation, performance by all three age groups declined. However, among the nine-year-old Black population, improvement occurred; Hispanic nine-year-old results remained constant. The areas of improvement for nine-year-old Blacks included knowledge and skills and understanding; their application scores did not improve. Thirteen-year-old Blacks did not decline overall over the five year period, but the seventeen-year-old group scores did decline during that period.

The magnitude of the difference between Black and Hispanic mathematics performances and that of the nation at the 17-year-old level is of primary concern. This figure (nearly 20% for Blacks) further confirms the fact that relatively few minority students achieve at a level high enough to consider entering careers in mathematics or science. The New York Times (1979) reported that there was a larger gap between minority and nonminority SAT scores in the area of mathematics than in the verbal area. Where average scores for Whites in mathematics was 493, for Blacks it was 359 and for Mexican Americans, 412.

Of the 15,816 Bachelor Degrees granted in Mathematics during 1976, 5.1% were awarded to Blacks, 1.6% to Hispanics, and .3% to Native Americans. Interestingly, more Black females earned these degrees than Black males. On the Masters level, 3.4% of the Mathematics Degrees went to Blacks, 1.4% to Hispanics, and .2% to Native Americans. During that same year, of the 853 Doctoral Awards in Mathematics, Blacks earned 1.1%, Hispanics 1.4% and Native Americans .1%.

The following three charts are drawn up from the results of the test.

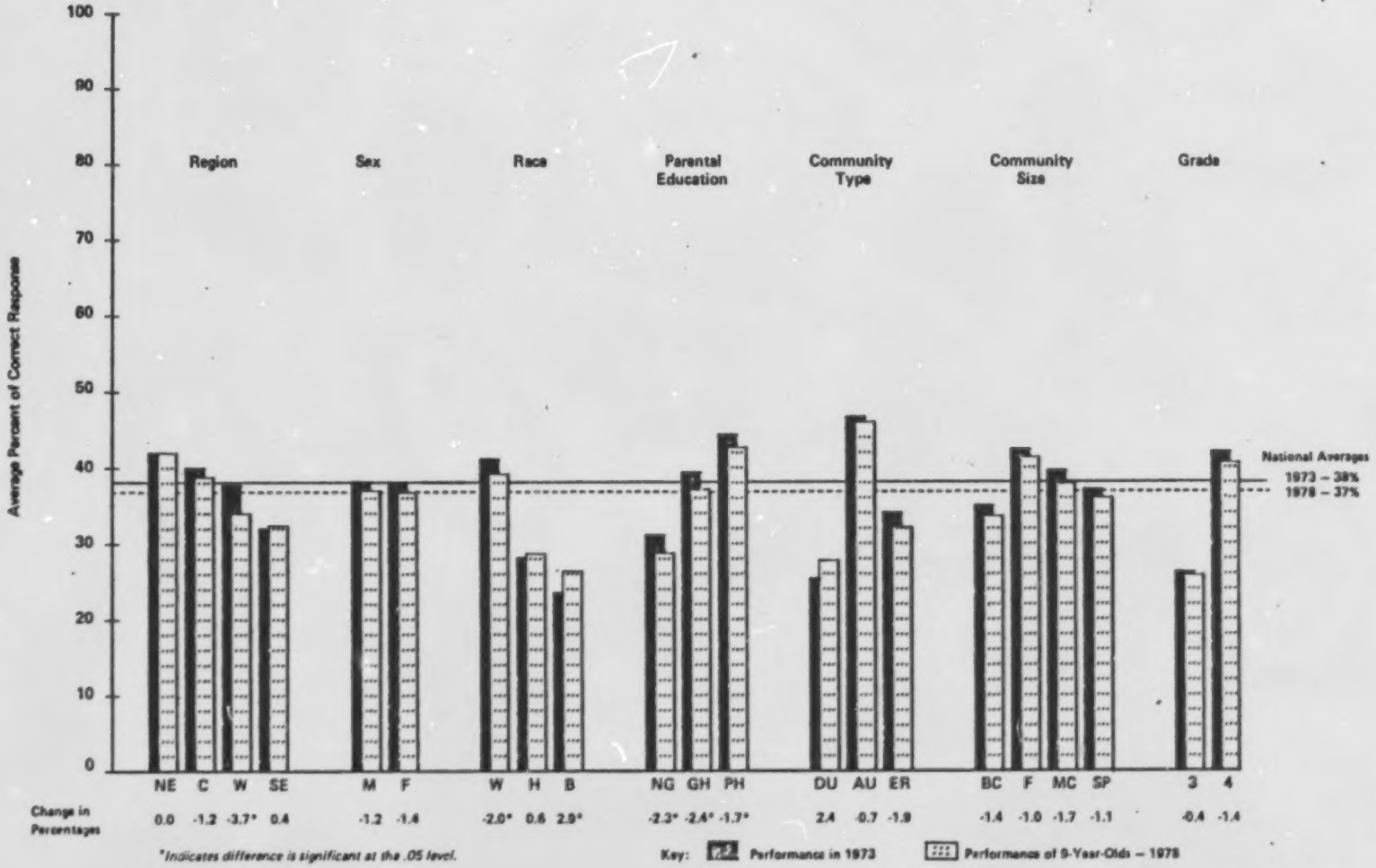
Chart 1: Average Percentages of Correct Response for Selected Reporting Groups on Mathematics Items - 1973 and 1978, Age 9.

Chart 2: Average Percentages of Correct Response for Selected Reporting Groups on Mathematics Items - 1973 and 1978, Age 13.

Chart 3: Average Percentages of Correct Response for Selected Reporting Groups on Mathematics Items - 1973 and 1978, Age 17.

CHART 1

Average Percentages of Correct Response for Selected Reporting Groups on Mathematics Items – 1973 and 1978, Age 9



Average Percentages of Correct Response for Selected Reporting Groups on Mathematics Items – 1973 and 1978, Age 13

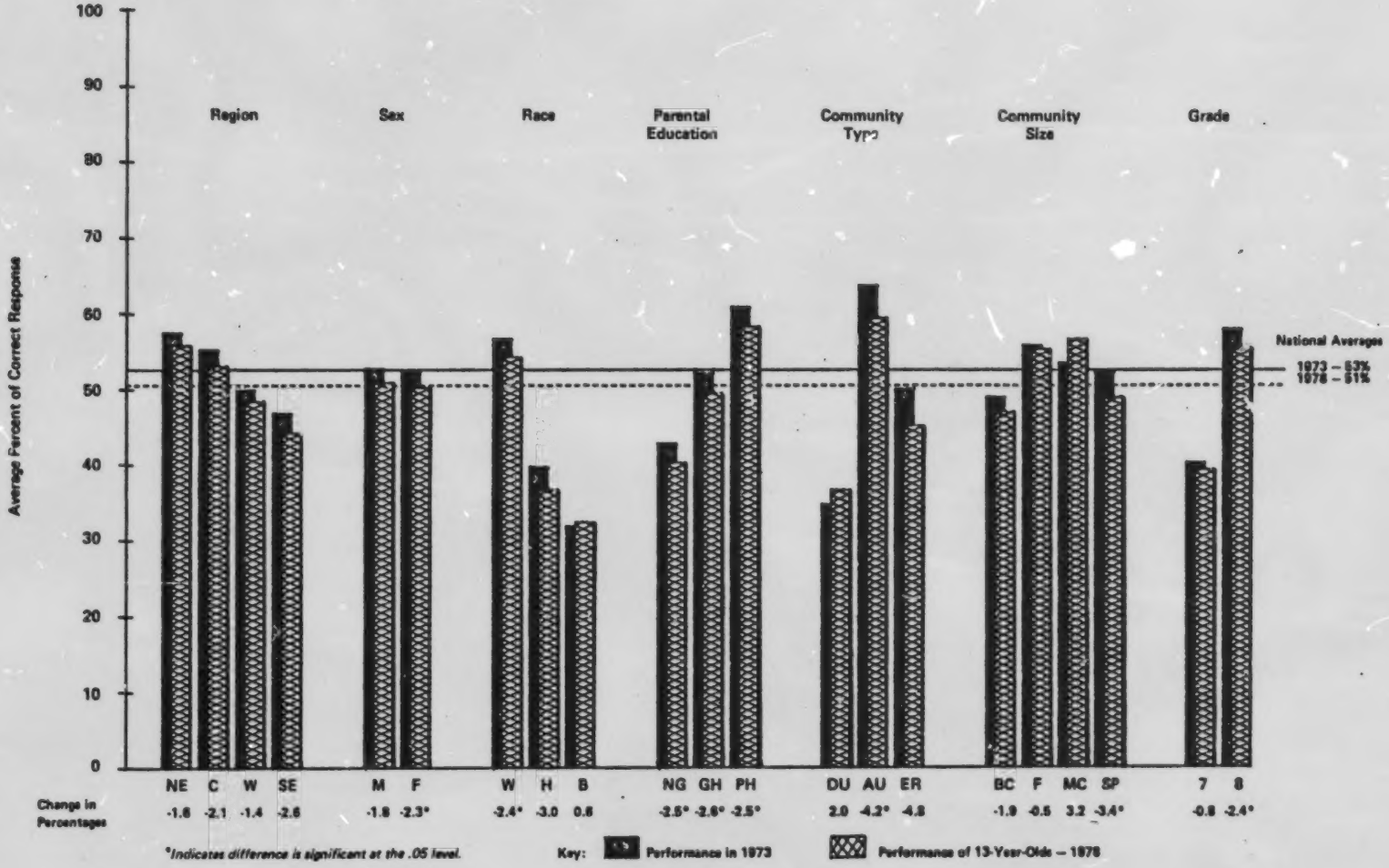
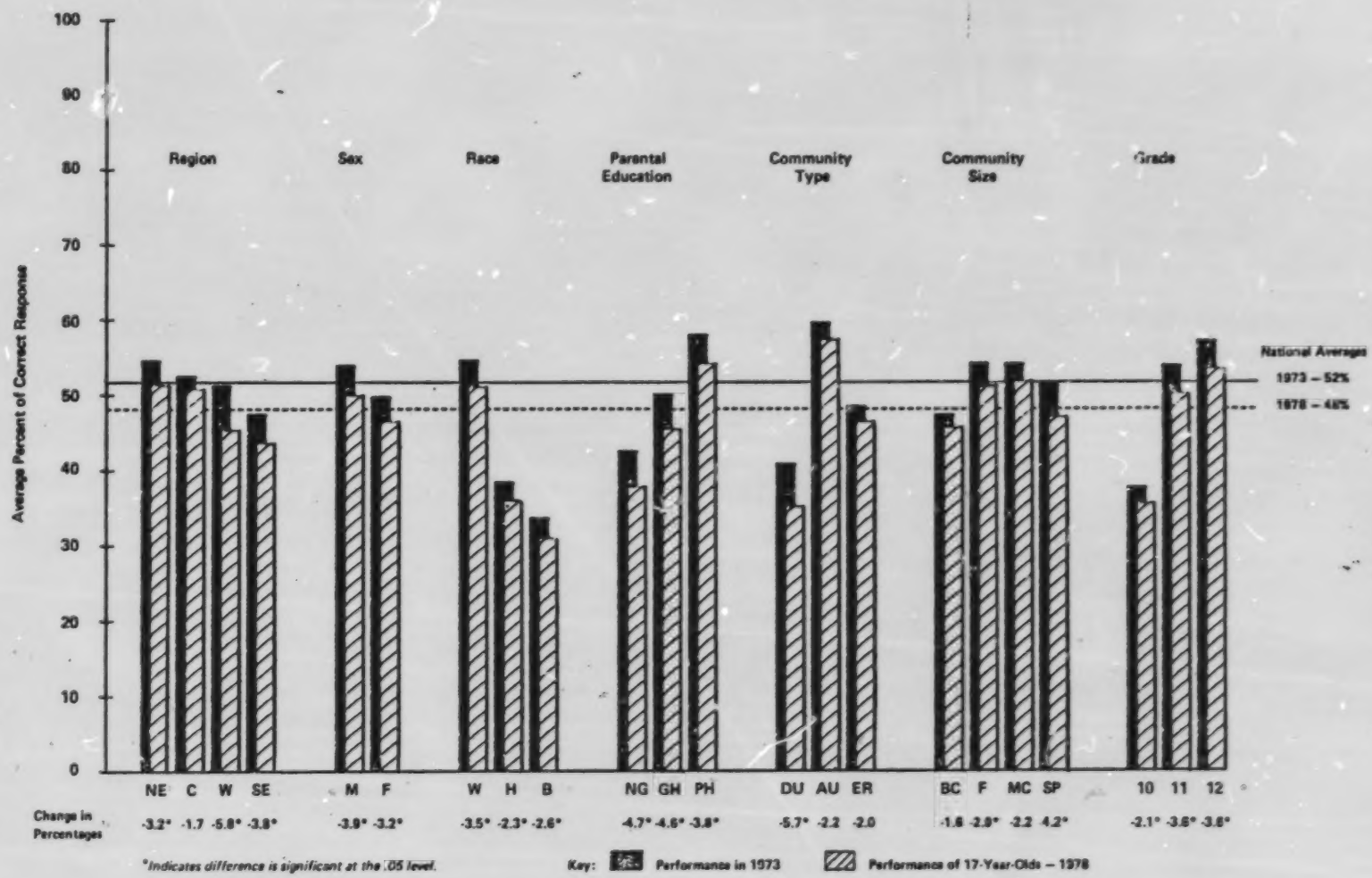


CHART 3

Average Percentages of Correct Response for Selected Reporting Groups on Mathematics Items – 1973 and 1978, Age 17



The National Science Foundation reported that 91% of the Doctoral Degrees earned in 1975 in Science and Engineering were awarded to White students. Scott (1977) found that although 16% of the White professional population are scientists or engineers, only 1.6% of the Black professional population hold similar occupations. In 1975, the National Science Foundation found that minority students who were identified as having the minimum level of science and mathematics achievement to pursue careers in those fields represented 10 - 15% of their total population. However, most of these students did not receive the necessary encouragement and financial resources to continue their education in these fields.

The data on the mathematics achievement of Native American students also indicate great disparities between their progress and that of White students. Of particular importance is the fact that as the Native American student moves on to higher grades, the gap between Native American and White achievement widens even more so than with other ethnic groups. Zimilies (1976) in his report on early childhood education needs of Native Americans noted that:

> "On the Choctaw reservation, the Metropolitan Achievement Test (Primary I) was administered to second and third graders. In the second grade, 60 of 67 children scored below the 25th percentile in Reading, and 38 children made equivalently low scores on the Math portion. The pattern was reversed among third graders in that performance was worse on the Math subtests. Seventy-two of 89 third graders scored below the 25th percentile in Math and 61 did so in Reading. Among 656 fourth to twelfth graders tested with the California Achievement Test, at least 75% of the children at each grade scored below grade level. Fourth and fifth graders were less than two grade levels below norm values whereas high school students scored more than three grade levels below norm values."

Bass (1971) interviewed high school Native American students and found that the majority of them perceived the necessity for learning mathematics. However, mathematics was the course most often repeated by Native American students and females failed these courses twice as often as males. The U.S. Civil Rights Commission agreed with Zimiles' findings in its Southwest Indian Report:

> ".... The difference between the performance of American Indian and that of White students widens with each succeeding year, especially between grades 10 through 12. The pattern was most pronounced in mathematics and least pronounced in reading. In mathematics, American Indians are 2.4 years behind White students in the sixth grade and 1.7 years behind the norm, but at grade 12, American Indians are 4 years behind White students and 3 years below the national norm."

An analysis of the error types made by Native American students on standardized tests reveals some intriguing results. On arithmetic, operational, and other strictly numeric questions, Native Americans compare favorably with White. However, in the problem solving and reasoning sections of the test the reverse occurs. Moreover, it was found that the score on the mathematical reasoning section, not computation or any of the verbal sections, tends to be the most accurate predictor of overall achievement. The severity of the implications of deficits in mathematics by Native American students is therefore compounded.

The causes underlying the status of participation and achievement in mathematics by Blacks, Hispanics and Native Americans are multi-dimensional. Students from these ethnic groups often demonstrate potential equalled to White students in the early grades. As their schooling experiences increase

during their elementary and through secondary years, many of them fall behind, drop out of mathematics and become negative in their attitude towards the subject. Hispanics and Native Americans have special difficulties because the language of the school often differs from their dominant tongue. In an attempt to identify some of the factors which contribute to this grave situation, three areas of concern will be addressed: effects of learning style, self-concept and personality on the mathematics learning of minority children, linguistic influences on their mathematics learning, and the effects of school with particular emphasis on teachers attitudes towards minority students in mathematics, the organization of mathematics classes, and the influences of guidance counselors on the career orientations of Black, Hispanic, and Native American students.

There are many other important elements which play key roles in determining a student's success or failure in a particular field. Influences of parents, community, socio-economic status, administrators, structure of the family, values of the culture, influences of peers, all intertwine and contribute to the profile of a learner.* However, the limitations placed upon this project demand that discussion of the three concerns mentioned be the primary focus of this report.

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*See Appendix A for additional research references.

SECTION II: Influence of Learning Style, Personality and Aspirations on Mathematics Achievement

Field Dependence and Other Related Learning Style Effects

Several attempts to show a direct effect of field dependence on mathematics achievement have been made; studies have also focused on the influence of cultural background on the field dependence of individual children. Field dependent persons take a larger amount of time to find embedded figures in a background than field independent persons do. Field dependent people usually prefer "people" occupations and they seem to excel in the social sciences field. On the other hand, field independent people prefer analytical thought courses and may aspire to sub-occupational fields such as engineering or mathematics. Field independent people usually prefer working alone rather than in groups. The source of field dependence and field independence has not been extensively addressed; one might hypothesize, however, that a combination of native and environmental elements determine the field dependences of an individual. The teachability of skills necessary to become either field dependent or field independent has also not been documented by researchers or educators.

Phipps (1977) identified a group of field dependent students and a group of field independent students in a traditional Philadelphia elementary school. After forming mixed learning style groups, Phipps placed one group in an open classroom and the other in a traditional classroom; then measured the achievement of these students in mathematics and reading, and found correlations between learning styles (field dependent or field independent) and classroom

environment. Field dependent children performed better in the traditional classroom than in the open classroom. Field independent children, however, performed equally well in both environments. A similar study by Horak (1977) tested the relative effectiveness of inductive vs. deductive mathematics teaching methods on field dependent students. She found that field dependent students tend to favor an inductive method of teaching; their ability to transfer their learning to new mathematics problems was enhanced with this technique. Edmeier (1978), in his study of the interactive effects of several variables, concluded that low achievers and field dependent students need a moderate amount of structure and direction; these students often suffer in more task-oriented mathematics classrooms.

Several researchers have shed light on the influence of cultural background on the field dependence of students. Ramirez and Price-Williams (1974) found that Mexican Americans are proportionately more field dependent than White students. Kagan and Zahn (1975) conducted a study with predominantely low income students in southern California; their results indicated a significant mathematics achievement difference between Mexicans and Whites. An attempt to relate this gap to field dependence and culture gave puzzling results, however. Neither of these factors consistently explained the mathematics deficit among Mexican American students. Kagan and Zahn did note, however, that culture affected and accounted for the major differences in reading. More recently, Buriel (1978) criticized the methods of Ramirez and Kagan for using only a single instrument in the measuring of field dependence. Buriel, on the other

hand, employed three measures: Portable Rod-and-Frame Test, Children's Embedded Figures Test, and the Wechsler's Block and Design Test. Mexican American and White children were used to test the relationship between culture and field dependence. Contrary to other researchers, Buriel found no significant cultural differences in field dependence and no significant mathematics achievement differences. Buriel suggests that the differences in field dependence and in achievement may be more related to economic status than to culture. Ortiz-Franco (1977) observed the mathematics word problem solving processes of Mexican American students in Union City, California. He looked for relationships among field dependence, mathematics achievement, mathematics reasoning ability and trial-and-error scores. No significant correlations among those variables was found in his study. Kagan and Zahn (1975) commented that, in their views, predominantly White controlled schools encourage achievement through field independent cognitive styles. They noticed that children from more restrictive families and cultural groups have a tendency to be more field dependent than others. These children have not developed the level of cognitive functioning or maturation which would allow them to be field independent. Acquisition of field independent skills is not related to the learning which occurs in schools, more attention must be given to identifying those skills and attempts should be made to institute a viable means for transmitting them to the students. The conflicting results of these studies indicate that a carefully controlled investigation of the relationships among: culture, field dependence, and mathematics achievement is necessary.

Other differences in learning styles among Black, Hispanic, and Native Americans may indicate alternative modes of addressing their educational needs. In mathematics, Burton (1975) found that low achievers were able to measure their performance significantly if given a variety of methods of instruction; variety, however, did not improve the achievement of high achievers. The question of open vs. traditional classrooms, directed vs. self-paced activities, single-method vs. multi-method instruction all continue to perplex researchers. Many of the recent studies resulted in little, if any, positive achievement effects among minority students using individualized self-paced mathematics instruction. Open classrooms have been criticized as being ineffective with minority students. Yet as Burton suggested and Morris (1978) concurred, variety of methods, psychomotor activities, and group interactive tasks are more conducive to the learning styles of minority children. Simpson (1977) suggested the inclusion of multi-dimensional, student selected materials which emphasize visual manipulation of mathematics concepts. Yet Fisher, Blackwell, Garcia and Greene (1975) found that in a low income school in California that although the students who were allowed to choose materials were more highly engaged in their work, the achievement scores in the no-choice group were higher. Perhaps the novel effect of the new materials utilized by the choice group prevented them from covering as much substance as the no-choice group.

The question of interest level, value patterns and their effects on the achievement of minority students was investigated by Banks, McQuater, and

Hubband (1978). They found that a high need for achievement for its own sake is not as prevalent among minority children as it is among White children. Suggested was a thorough analysis of the interest areas and internal values of minority children; this would assist educators in fostering better support between students and learning materials. Meissner (1975) took a close look at the patterns of learning relational concepts by inner-city students. She discovered that concept formation with these students is often highly developed. Weaknesses prevail, for the most part, in the area of communication. Minority students tend to be reluctant to speak up during class discussions; they often answer questions with brief responses. In addition, low self-confidence and lack of comfort in ethnically-mixed environments contribute to the hesitancy of Black, Hispanic, and Native Americans to verbalize openly in the mathematics classroom. More time must, therefore, be spent with these children on communicating the ideas which they have skillfully conceptualized. As Doebler (1977) pointed out, teacher awareness of the educational implications of student learning styles would have a positive effect on the achievement of these children.

Effects of Hemispheric Specialization

One of the more recently-studied factors which may contribute to the underachievement and non-participation of minority students in mathematics is the dominance of either the right or left hemisphere of the brain. The left hemisphere is better at such tasks as reading, speaking, analytical reasoning, and arithmetic, while the right hemisphere is better at spatial tasks, recognizing

faces, and music. The majority of our educational programs have been geared toward left hemisphere activities. There is a growing body of evidence that sex differences and socio-economic and cultural differences in processing do exist. (Wheatley, 1978). In the mathematics classes of most elementary schools, teachers gear their lessons toward the use of cognitive skills such as memory and practical application (Heimbuck, 1977). These skills would be classified as left hemisphere processes; much of the thrust is placed on the basic operations, addition, subtraction, multiplication, and division. Students who have more success with visual tasks, such as geometric activities, have little opportunity to utilize these strengths, and they experience much less success in handling the concepts presented in other contexts. Both sides of a child's brain should be developed; stressing activities which stimulate only one side deprives all children of reaching their full potential, whether they are left or right hemisphere oriented.

Knowledge of the preference for one side of the brain by Black, Hispanic, or Native American children should stimulate changes in teacher training colleges, inservice training programs, educational materials companies, and parent workshops. For example, more visuals could be used to teach the fundamental concepts of whole numbers and fractions. Geometric materials such as tangrams, pentominoes, cubes and pattern blocks would serve as invaluable tools to stimulate right hemisphere activity. John-Steiner and Osterrvich (1975) discussed the strong emphasis on visual rather than verbally-based acquisition of information in Native American societies. They found that Native Americans

communicate more effectively using image rather than verbal narration. This visual preference indicates the possibility of right hemisphere dominance in these people. Other researchers have focused on the question of differences in hemisphere specialization and on how those differences relate to cognitive development in mathematics. Wheatley (1973) suggested that Piaget's theory on the stages of cognitive development; sensory motor, pre-operational, concrete operational, and formal operational may be explained to some degree by the development in brain functioning. The average beginning age for hemispheric specialization is about eight years; this occurence seems to correspond with the stage of concrete operational thinking. Whyle (1977) found specific patterns of cognitive and spatial development characteristics in children of differing achievement levels. She also related spatial ability to age.

Many studies have supported the finding that infants and young children tend to be right hemisphere dominant in their approaches to tasks, where adults tend to prefer the use of left hemisphere processing. Therefore, somehow in childhood a shift occurs in many individuals. Just when and to what extent this is true even for the general population remains in question. Julia Sherman (1974) concluded that the female establishes early preference for verbal approaches and, given educational and societal influences, she tends to solve all types of mathematics problems with the use of the left hemisphere. This fact sheds light on some of the sex differences noted in mathematics achievement. Patricia Davidson is employing a neurobiological model to study

the relationship between degree of hemispheric specialization and mastery of specific areas of mathematics. Moses (1977) discovered spatial ability and mathematics problem solving ability to be highly correlated. One often feels that certain people were "born problem solvers"; Moses, however, strongly believes that spatial ability can be developed and modified by instruction. Certainly, more emphasis on geometric perception would provide opportunities for students to stretch their spatial capacities. Clement (1977) pointed out that all children have intuitive knowledge structures and reasoning processes which need to be tapped early in their mathematics education. Giving them experiences in using these natural faculties strengthens their problem solving abilities and reduces their chances of failure in higher mathematics courses. Coppus (1978) suggested computer programming as a viable tool for developing both the right and left hemispheres of the brain. Kemp (1978) tested the effects of varying left and right hemisphere oriented activities on the science achievement of fifth grade students. She found that there was no significant achievement difference. The inclusion, therefore, of right hemisphere materials for those students who tend to prefer using this side of the brain would not impede their progress and should result in higher achievement.

Effects of Self-Concept, Locus of Control, and Aspirations

"Public opinion is a weak tyrant compared with our own private opinion. What a man thinks of himself that it is which determines...his fate." (Thoreau, Walden, 1854.) Black, Hispanic, and Native American children have, historically, maintained low self-images. Howell (1978) assessed the positive and

negative influence on the self-esteem of students from these three ethnic groups. Blacks and Chicanos rated home and peers as positive influences on their self-esteems; school and teachers were listed as negative influences. All three groups saw themselves as better off than their teachers saw them. Battle and Rotter (1963) found children's feelings of personal control to be related to social class and to ethnic group. The self-concept of the bilingual/bicultural child was studied by Reyes (1976). He found that these children are faced with continual values conflict when placed in American schools. Many of these students allow themselves to behave in ways which, they perceive, others expect of them. In mathematics class, they become passive learners of only the rudimentary elements of the field. Mathematics learning demands an open, searching mind - one which ponders ideas, formulates hypotheses and discovers new relationships. To be successful in mathematics one must feel a sense of personal control and self confidence.

Of the three ethnic groups under consideration, the Native American people constitute the most unique. There are approximately 600,000 Native Americans belonging to 300 various tribes in this country. Research about the attitudes and achievement of these people do enlighten our understanding of the educational situation among Native Americans. McClain (1977) commented that the lack of desire to assimilate places Native Americans at a great disadvantage when faced with the present institutions of education. Native Americans have a strong commitment to their culture, a keen sense of community, generosity, and sincerity. They have no interest in a technological society if it fails to offer a significant improvement in the quality of their lives.

Riner (1977) interviewed members of 174 Native American households; he found that most of the participants considered school an agent of forced acculturation. As Native American students progress in school, their level of self-concept was found to decrease. The most severe decline in self-concept appeared among junior high school students. According to Green (1978) many Native Americans "think twice and sometimes quite finally about certain careers in scientific and technical fields because of a perception of themselves as hopelessly incompetent in the mathematical skills needed for the career." Native Americans were lowest in self-esteem when compared to Black and Hispanic Americans. Thus, the maintaining of a low self-image by minority students does influence the way they approach mathematics. (Gordon, 1977.)

In 1977, Oscar Glantz studied the relationship between locus of control and aspirations to traditionally open and traditionally closed occupations. A person's locus of control is considered internal if he/she feels personal contol over his/her own destiny. If one's locus of control is external he/she feels powerless and is unable to determine his/her own future. Since mathematics related professions include relatively few minorities, these occupations would be termed traditionally closed. Glantz found that high internal control was positively related to risk taking among American Blacks. More high internal students chose to venture out into the traditionally closed fields than high external Blacks. There have been mixed results in studies regarding locus of control and mathematics achievement. May (1978) found no significant relationship. Schneider (1977) and Brunner (1975) concluded that

a child who feels powerless and hopeless (i.e., external locus of control) has great difficulty investing him/herself in anything which does not result in immediate gain. Consequently, an external locus on control may deter the mathematics achievement of such students.

Does the racial composition of a student population affect the locus of control of these students? Wilson (1977), Dodson (1977), and Weinberg (1977) provided some insight into this issue. Wilson found that Black students who attended all Black colleges had slightly higher levels of internal control than did Black students at predominantly White colleges. Dodson assessed the locus of control factor with three groups of Black students; in all Black colleges, 40% Black colleges, and 5% Black colleges. He discovered that the students in the 40% Black category were more externally controlled than either of the other groups. Weinberg, however, in his appraisal of minority students concluded that desegregation does increase a student's degree of personal control. It is, therefore, impossible to assert that the racial composition of the classroom, by nature, has a predictable effect upon locus of control. The importance of the issue must not, however, be diminished.

Discrepancies betweem minority student aspiration and actual plans for attaining them may seem to indicate a lack of commitment or general apathy towards work in these populations. For the most part, however, the economic situation in which many Black, Hispanic, and Native Americans exist determines the extent to which they will be able to realize their objectives. Thomas, Kravas, and Low (1979) listed pessimism about chances of success and lack of vocational models as factors which deter minority students from their original

goals. Both Thomas, et al., and Parham (1978) found that Black youths chose occupations that were open and financially rewarding rather than those to which they had attached significant personal value. This is not surprising given, once again, the limited financial resources of minority people in this country; also Blacks, Hispanics, and Native Americans have experienced past frustration in so many areas - jobs, housing, schooling, etc., that they have conditioned themselves not to count on their dreams and aspirations coming true.

Some differences in the ambitions of low-income Black children as opposed to upper income Blacks can be seen in the following table prepared by Regina Goff. (Wilcox, 1971.) Only the upper-income older boys aspired to mathematics or science related fields.

Lower-income boys		Upper-income boys	
6-8 year olds	26% fireman, policeman	6-8 year olds	34% fireman, policeman
	24% brick mason, builder, mechanic		32% builder, mechanic
	27% lawyer		14% real estate agent
12-14 year olds	40% big league ball player	12-14 year olds	46% doctor, lawyer
	27% doctor		20% scientist
	14% contractor		10% architect

Lower-income girls		Upper-income girls	
6-8 year olds	34% teacher	6-8 year olds	34% teacher
	15% entertainer		26% nurse
12-14 year olds	30% entertainer	12-14 year olds	37% teacher
	10% secretary		27% entertainer
			14% secretary

More significantly, however, were the responses of these students regarding their chances of reaching their stated goals. More of the lower-income students were insecure about their chances. As possible interferences, low income students named lack of opportunity and lack of money as the major obstacles. Upper-income students felt that only ill health, bad luck, death, or physical disability would keep them from attaining their objectives. Newby (1976) found that minority students in segregated settings set higher aspirations than those in desegrated environments. He did not, however, compare the relative percentages of actual achievement of their expressed goals.

If minority students are to involve themselves wholly and spontaneously in any academic area, a trusting educational environment must be established. Once accomplished, these students will feel more free to relish new and intriguing ideas and to pursue more unfamiliar career paths. Colclough and Lilley (1978) studied the perceived blockages in the occupational attainment of Black youth. They classified the blockages into two types: structural and individual.

The structural barriers faced by minority people involve the dynamics of our social and economic system. Personal characteristics and experiences cause individual blockages. It is these individual blockages which this chapter has addressed; with more understanding of the factors of learning style, locus of control, self-concept and personality, it is hoped that destruction of these blockages will lead to the participation of more Black, Hispanic, and Native Americans in the mathematics and science fields.

SECTION III. Linguistic Effects on Mathematics Achievements

In light of the data showing significant differences in the mathematics achievement of Hispanic students when compared to Whites, the issue of language influence emerges as a key element in the learning of these children. The question of whether Hispanic children differ academically from non-Hispanic children before attending school was addressed by Anastasi (1953). She tested fifty Puerto Rican pre-schoolers and fifty White and Black children of the same age. Her findings indicated equal norms for all three groups, underlying that the home life of these Puerto Ricans acted as a positive influence in early linguistic development. Anastasi hypothesized that the inferior performance of older Puerto Rican children may be a result of cumulative effects of low socio-economic status and the intellectual and emotional effects of bilingualism in the American school setting.

Of the many studies which measured the effect of bilingualism on intellectual functioning, a large portion found a negative correlation, that is, bilingualism had a detrimental effect on intelligence. A small number of studies found little or no effect and three studies reported that bilingualism has a positive effect on intelligence. One such study was conducted by Lambert (1972), who also criticized the methods and sample selections used by other researchers. Lambert chose instruments which would diminish the possible effects of a language handicap; that is, her felt that verbal tasks would invite inter-lingual interference more often than non-verbal tasks. Consequently, Lambert's choice of the Primary Mental Abilities Space and Perception Tests and

the Primary Mental Abilities Figure-Grouping Tests reflected this concern. Lambert discovered that non-verbal intelligence was indeed influenced positively by bilingualism. Both monolingual and bilingual groups scored similarly on spatial visualization tasks, but the bilingual group scored higher on the mental manipulation tasks. Several reasons have been advanced for this superiority of bilingual students. A bilingual child, in acquiring two languages automatically learns two symbols for each object. This forces the child to conceptualize his/her environment in more general terms in order to avoid reliance on linguistic symbols. Bilingual children develop more flexibility in their thinking and, thus, possess a more diversified set of mental abilities. They are able to attack problems in a more abstract manner and have had experience in switching from one mode of operation to another. Monolingual children are less prone to develop such capabilities at an early age. The study just discussed was conducted in Montreal, Canada with a group of ten-year-olds taken from six middle class French schools.

The potential of bilingualism having a positive effect on intelligence and mathematics achievement is there. This question, posed by Cummins (1979) deserves serious attention: "Why does a home-school language switch result in high levels of functional bilingualism and academic achievement in middle class majority language children, yet lead to inadequate command of both first and second language and poor academic achievement in many minority language children?" Cummins suggested that a closer look at the interaction between socio-cultural, linguistic, and school program factors be undertaken. Perhaps

too much emphasis is being placed in socio-cultural and school program variables to the detriment of linguistics. More use of the conceptual linguistic knowledge inherent in the bilingual child would provide opportunities for him/her to develop thorough understandings of mathematics ideas.

The inadequacy of standardized achievement and I.Q. tests for non-standard English speakers was proclaimed by several researchers (Zirkel, 1972). For Spanish-speaking students, Begle (1975) found no adequate translation of the Wechsler or the Stanford-Binet intelligence tests. When only the instructions were given in Spanish no significant improvement resulted. In one Begle experiment, however, he proivded both White students and Mexican American students with prior exposure to the test making strategies and to the nature of the concepts to be presented on the test. The Mexican American students benefited from the intervention while it made no impact on the performance of the White students. On non-verbal tasks, Begle found that second grade Mexican American students performed as well or only slightly below second grade White students.

Shellenberger (1977) examined the Spanish version of the McCarthy Scales of Children's Abilities. This test tends to be less culturally loaded than other standardized tests; it also includes measures of verbal, performance, quantitative, memory, and motor functioning, thus giving a fuller profile of a child's capabilities. In Shellenberger's study of the validity of the McCarthy Scales, she noted large discrepancies between the nonverbal and verbal scores of Spanish language dominant children. The quantitative and perceptual performance scales proved to be the best predictors of total achievement, not

only mathematics achievement in school. It was felt that quantitative tasks most nearly paralleled skills taught in school; perhaps these children also prefer to use their perceptual skills and nonverbal concept formation abilities to handle all types of academic material. Shellenberger's sample included equal numbers of children in Puerto Rico and in the United States. She found that the gap between verbal and nonverbal scores was greater within this country, indicating that the Spanish language development of Hispanic Americans often declines once they enroll in American schools. In any case, Shellenberger recommended the use of sub test scores (specifically the quantitative and perceptual performance scores) of the McCarthy Scales of Children's Abilities for accurate placement of Hispanic students in mathematics as well as other fields.

Some educators prefer to use pictoral testing materials as a replacement for verbal questioning of Spanish-speaking students. Padilla and Romero (1976) found that these pictorial devices often contain distracting cues; they felt that verbal questioning in the dominant language of the student would yield more positive results.

Baecher (1977) studied the linguistic effects on the learning styles and preferences of Hispanic children. He noted differences between Hispanics and Whites in listening comprehension, symbolic meaning, cultural influences, reasoning patterns, and "theoretical visual linguistic" ability. This last skill refers to a child's ability to think abstractly and to conceptualize one's environment through imagery. In Baecher's observation of Mexican American elementary school children, he found that they preferred activities which

involved listening rather than reading. This suggests that more oral problem posing in mathematics would be effective with these students.

The dependence of word problem solving ability in language development deserves discussion. On the college level, Cossio (1977) studied the results of the Mathematics Placement Test given in both English and Spanish. The fully bilingual students, whose background in mathematics was firm, performed better in the English version of the test. Other students, more Spanish dominant or less prepared in mathematics, performed better on the Spanish version. Mathematics problem solving ability continues to be linked by many to verbal ability in English. Minority group children perform significantly better on arithemetic computation than on mathematic word problems. Goodrun (1978) found that as a child's language skills improved, the gap between his/her computational and word problem solving abilities decreased. For many Hispanic students, facility with Spanish reading and with English reading are equally difficult. The importance of language proficiency of bilingual students cannot be overemphasized. Merino (1979) studied the relationship between teachers' Spanish proficiency and students' achievement. She found that bilingual teachers' scores on the Teachers' Spanish Proficiency Test did correlate with students' scores in English. Skilled bilingual teachers serve not only as effective teachers of Hispanic students but also represent positive role models so desparately needed by these children.

It is not imperative, however, that the mathematics development of a child be hampered by his/her language deficiencies. Alternative ways of using the

strengths of Hispanic children, especially their abilities to handle nonverbal and perceptual ideas, should be made available.

The research on the effectiveness of Spanish-English bilingual programs contains conflicting results. The Stanford Mathematics Education Study Group under the direction of George Begle reviewed the literature on mathematics achievement of Mexican American students enrolled in bilingual programs. (Begle, 1975.) Students who were involved were either bilingual (Spanish-English) or monolingual Spanish; they resided in the Southwestern and Western sections of the United States and the majority of these students came from families of low, socio-economic status. As a result of bilingual instruction, first graders made improvements in oral comprehension of concepts and in fundamentals (computation). No improvement in reasoning was found for the first graders. In the third grade, however, significant progress in reasoning and concepts resulted while computation showed no improvement. No significant differences in ninth grade mathematics achievement were noted after participation in a bilingual program. Begle concluded that different information processing strategies operate in the minds of children whose primary language is not English. More research on the nature of these differences would be valuable.

Denker (1977) also found many inconsistencies in the literature on bilingual program effects. Her study of numeric concepts, however, yielded interesting results. These Hispanic students who received instruction in Spanish performed as well as non-Hispanic students whose lessons were conducted in English. Among the Spanish-speaking students there was a higher correlation

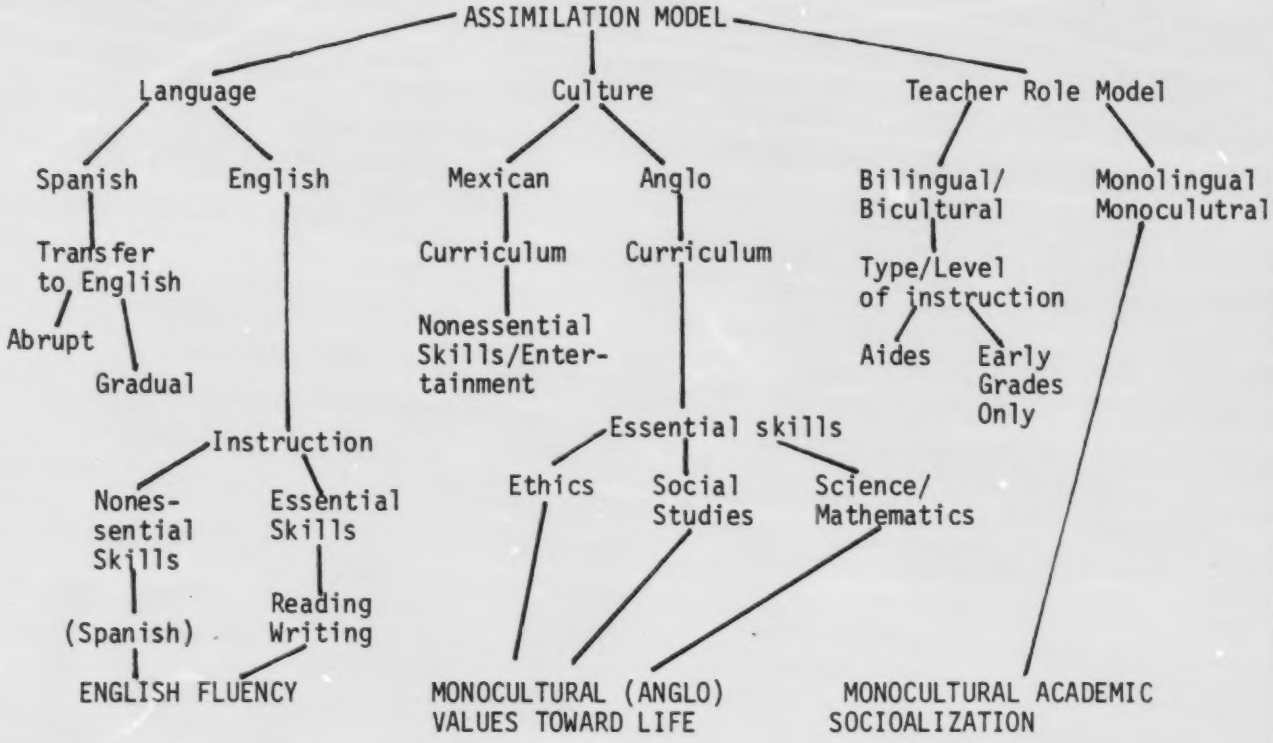
between test scores and general mathematics ability than there was among non-Spanish speaking students. This suggests the importance of providing a solid foundation in mathematics for bilingual students. Much subsequent concept formation depends on established proficiency.

Lopez (1978) suggested reasons for the lack of consistency in the achievement gains of bilingual programs. He feels that the programs would be successful if more attention is given to these three elements: inservice education for teachers, parental involvement, and self-concept development. At appropriate times, instruction in English should be incorporated. Gallegos (1978) developed more specific guidelines for a course in mathematics for bilingual teachers. His proposed guidelines emphasized these four components: the development of basic Spanish and English vocabulary for each topic, the expansion of the curriculum to include underlying rationale and theory in mathematics, familiarity with nonstandard topics such as geometry, probability and statistics, the metric system and number theory, and the inclusion of concrete materials and activities for the bilingual child.

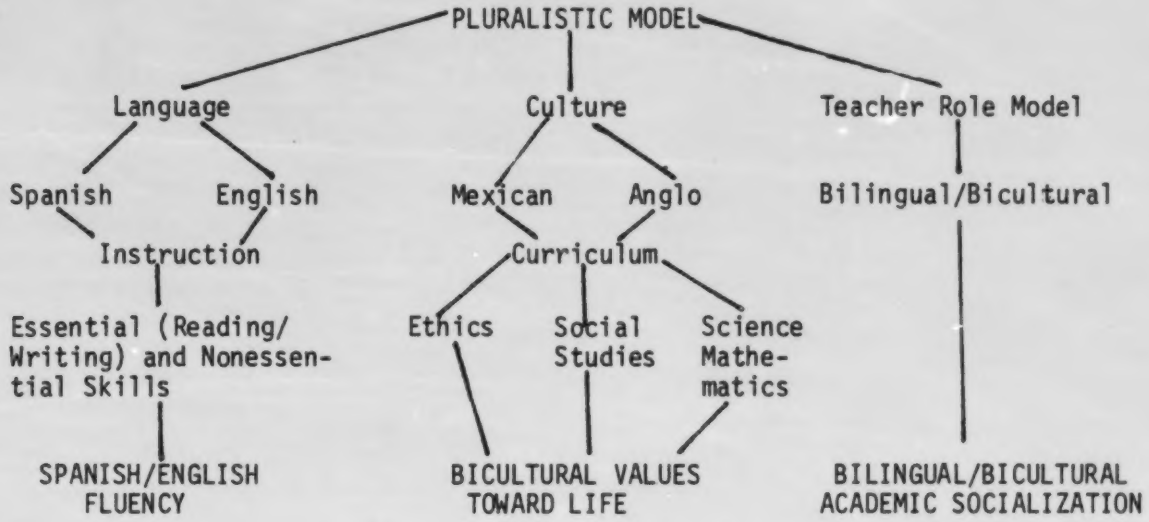
Padillo (1977) presented models for the three types of bilingual programs which operate in the various school systems in the United States. His models were based on the Mexican American population because this group constitutes the largest non-English speaking population in the country. These models appear on the following pages. Padillo pointed out the differences in the instruction of mathematics and science among the three typologies. In the assimilation type program, all of the essential skills (which include mathe-

matics) are conducted under the Anglo cultural and curricular influence only. The pluralistic model takes both cultures into account in the mathematics instruction, giving the child a better sense of personal involvement and control. The separatist plan handles all of academic areas with the exclusive use of the Mexican culture and values. Possible effects of the type of bilingual program on the mathematics achievement of Hispanic children has not been well researched. Once accomplished, however, school administrators will need to reassess their current programs and make the necessary reforms.

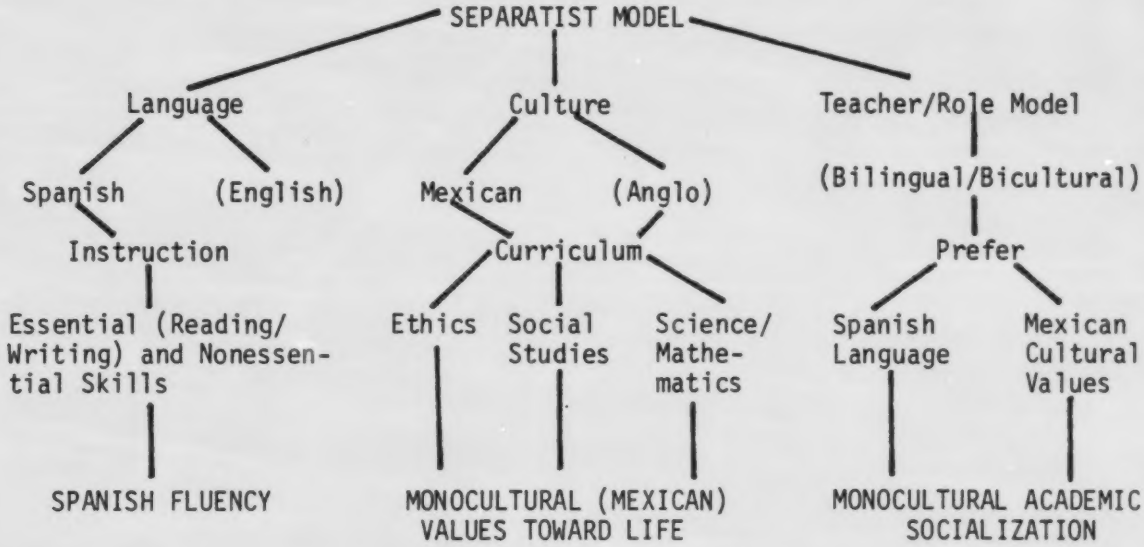
Typology of the Assimilation Model



Typology of the Pluralistic Model



Typology of the Separatist Model



SECTION IV. School Effects on Mathematics Achievement

Relative Effects of School

Determining the effects of school relative to the effects of home environment and family background has been difficult for researchers. The major problem has been the separation and combination of variables in a manner which yields direct and indirect effects of each element. In the original Coleman Report (1966) school was reported to have a minor effect on the achievement of minority children; their academic progress was said to be accounted for by social class and peer group composition. In 1975, Coleman reanalyzed this data and found greater effects of school than he had found heretofore. Mullis (1978) performed an in-depth study of the relative effects of school and home on mathematics learning, political knowledge, and attitude. He used the data collected by the National Assessment of Educational Progress with a sample of 10,000 seventeen-year-olds nationwide. Mullis found that in mathematics the direct effect of school was greater than the direct effect of home. Relative to home, school had a higher effect on mathematics than on either political knowledge or attitude. The total effect of home, which included those effects of home implemented through the school, was slightly larger than the direct effect of school (school was 0.92 as great as total income). The most important school instruction variable was exposure to subject matter. The students who scored highest in mathematics, even on basic topics covered in their elementary school years, had taken more mathematics courses than the poorer performances. Apparently, the continuing familiarity with the subject played a large part in their performance.

Weinberg (1977) referred to a finding of Mayeske that school has a more significant effect on the mathematics achievement of Blacks, Hispanics, and Native Americans than on that of Whites and Asians.

Effect of Tracking

Misuse of standardized intelligence and achievement tests often places minority students in inappropriate mathematics classes for instruction. In the State of California in 1977, 21% of the children enrolled were Black or Mexican American; however, 52% of the pupils in EMR (educable mentally retarded) classes were Black or Mexican American. Other studies (Lanier, Wittner, 1977) showed that teachers are more prone to referring non-White students to EMR classes than White students. In addition to test results, teacher attitudes toward non-White children must influence their referral decisions. Tracking by ability for academic subjects has become an accepted mode of operation in most school systems. Brown (1978) discussed the disproportionate number of minority students in lower ability level tracks; he feels that such resegregation inside the schools constitutes denial of equal educational opportunity. In effect, a dual school system results when minority students are placed in low level tracks. Also, since there are corresponding distinctions made in curriculum the possibility of changing tracks is slim. Brown, therefore, concluded that these students naturally get channeled into lower level occupations. In Weinberg's (1977) research appraisal on minority students, he found that the track effect was greater than the race effect, when accounting for differences in mathematics. The differences in the cumulative processes of experiences

that take place especially after the age of eight widen the gaps between the races. According to Weinberg, the effect of school on mathematics achievement for these three tracks: vocational, business, and college preparatory was 36.2%, 27.3%, and 63.7% respectively. Thus, students in higher level tracks reap more benefits from the educational system.

In the administration of schools, delegation of teaching assignments often reflects the prevailing attitudes about the various tracks. Weinberg (1977) and Scott (1978) both found that lower level mathematics classes and mathematics classes in urban schools with heavy minority enrollments are taught by less experienced, ill prepared teachers who often have negative attitudes toward mathematics. Scott asserted that if we are to meet the challenge of improving mathematics education in the urban schools, the finest and most effective teachers must be employed.

Effects of Teachers' Attitudes Toward and Expectations of Minorities in Mathematics

Numerous studies of teacher attitudes have been conducted during the last five years; Roger (1978) reported that the alienation between teachers and students in the urban schools has become increasingly grave. In a three year study conducted by Roberta Bernstein (1978) teacher behaviors toward minority children were analyzed with unfavorable results. Teachers repeatedly degraded their students by negative evaluative remarks about their work; they seemed to focus excessively on the weaknesses of these children, ignoring their strengths. They offered little opportunity for minority students to

take initiative or to share in responsibilities of the classroom. Bernstein felt that the academic preparation given to these students pointed them towards subordinate social and economic positions. This lack of teacher responsiveness to differences in learning styles and cultural backgroundsoccurred several times in the literature (Lee, 1978; Raines, 1976; Austin, 1976; Briggs, 1977). The "self-fulfilling prophecy" theory also continues to operate, according to those who have studied the situation of mathematics achievement among minority children. Since the nature of mathematics readily lends itself to varying degrees of cognitive development, teachers tend to adjust the scope of the curriculum to suit individual groups of children. It is convenient for teachers, therefore, who have predisposed opinions about the students' potential, to narrow the spectrum of the mathematics content as they see fit. In one study by MacQueen (1978) two groups of minority students were involved. Those students whose teachers believed that race and income were <u>not</u> determinants of success showed greater gains in achievement than the other group of minority students.

There is more evidence that teachers' expectations of minority students in mathematics often have to do with non-school variables and not student performance per se. Lambert (1972) assessed the influence of speech style on teachers' attitudes toward students. Preservice teachers listened to students' voices, viewed their photographs, and were given samples of drawings and compositions; each was asked to evaluate the academic potential of each child. Lambert discovered that the ratings of those students with poor drawings and compositions were influenced by their voices and by their physical appearances.

Those with "good voices" were thought to be more confident, mature, and intelligent than those with "poor voices". The ramifications of these results for Black English speaking children and Hispanic children are disturbing. Similarly the assessing of a student's academic capability with the use of a photograph, no matter how small the effect, indicates that irrelevant teacher prejudices could determine a child's education progress. Cooper (1975) considered the effect of socio-economic class on teacher's expectations; his results showed that preservice teachers expected middle class students to receive higher grades than lower class students. These teachers felt that White middle class students are held more internally responsible for their failures than Black students. The differences in task orientation, interest value, and locus of control of students also contributed to the expectations of the teachers. Teachers should not judge an entire group of students by their family income status; diagnostic measures must be used to delineate individual differences.

A few researchers observed the reinforcement patterns of teachers in mathematics classes as they related to minority children. Vasquez (1974), in his assessment of the problems of low achieving Mexican American students, found that teachers tend to praise White children more often than Mexican American children. Heller and White (1975) compared the rates of teacher verbal approval and disapproval in higher ability classes to those given in lower ability classes. Their sample consisted of low income public school and junior high students. They found that teachers emitted far more disapprovals in the lower ability classes than in the higher ability classes. There also

were more disapprovals than approvals given in the low ability classes. Byalick and Bersoff (1974) also witnessed a low rate of reinforcement emission in his observation of integrated classrooms. They noticed other interesting dynamics at work in these classes. Males were reinforced more than females. Black females received the least amount of reinforcement from both White and Black teachers. Only one-third of the teachers actually used the type of reinforcement which they had earlier declared to be most effective. The student-teacher interaction has much to do with a student's success in mathematics. Cooper and Petrosky (1976) and Miller (1977) found a positive correlation between student attitude towards mathematics and support from his/her mathematics teacher.

A group of pre-school children from low-income families was observed by Beche (1978). The most successful mathematics experiences of these youngsters occurred in classrooms where teacher involvement was minimal. In fact, as teacher judgement of their work increased, the student's achievement decreased. At this early stage, children can become actively engaged with mathematics materials which are self-teaching tools. However, the importance of teacher-student rapport in the later years increases substantially.

Burg (1975) found that some teachers in inner-city schools do set their expectations by the performance of their students. However, since performance standards are so low, the teacher's expectations are correspondingly low. Once again the situation of Pygmalion in the classroom appears. Cooper (1979) established a model for teacher expectation, communication, and per-

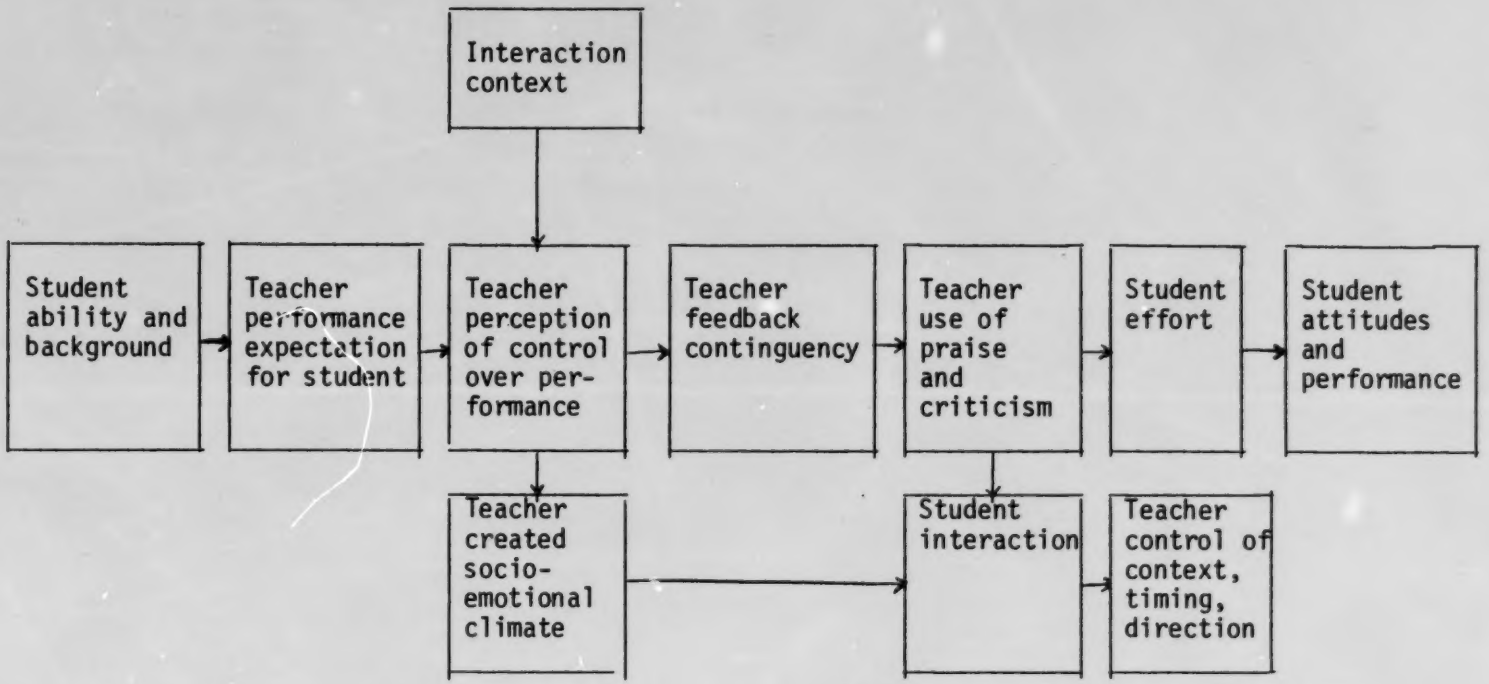
formance influence. With this model, teachers may begin to understand the dynamics of their interactions with students, the appropriate points of intervention, and they may work to make serious improvements in their relationships with minority students in mathematics. The Cooper model appears on the following page.

Other Instructional Concerns

Newby (1976) noted the differences in mathematics instructions of Black students as opposed to White middle class students. He witnessed the negative feedback given to Blacks and the emphasis placed upon drill work and rote learning in classes of minority students. The middle class children, Newby commented, were being socialized and educated for higher achievement and leadership roles in our society.

Kennedy (1977), Bridgeman and Buttram (1975), Taback (1975), also discussed curricular concerns about inner-city mathematics instruction. Kennedy observed kindergarten teachers who emphasized the writing of mathematics symbols. She found that the students' understanding of mathematics had little relationship to their ability to write the standard symbols. Kennedy suggested the use of concrete materials and informal symbols as a better means of achieving genuine success in mathematics at this stage. Bridgeman and Buttram analyzed the race differences on the non-verbal sections of the Cognitive Abilities Test. In the first level, which required rote learning and primary memory facility, there were no race differences found. However, there were significant race differences on the level two activities; these level two tasks in-

Pygmalion Grows Up


Interaction context
Student ability and background
Teacher performance expectation for student
Teacher perception of control over performance
Teacher feedback contingency
Teacher use of praise and criticism
Student effort
Student attitudes and performance
Teacher created socio-emotional climate
Student interaction
Teacher control of context, timing, direction

A model for Teacher Expectation, Communication and Performance Influence

volved reasoning and conceptual thinking. Bridgeman and Buttram pointed out that the skills required for the level two activities are often learned in non-school contexts. They recommended that schools begin to teach these skills explicitly as part of the mathematics curriculum. In this way, the non-verbal abilities of Blacks and other minority students would have an opportunity to expand; some of these students would meet with more success in mathematics classes in later years, and some may choose career paths in these fields.

Taback made three observations in a mathematics class of third grade inner-city students. He noted the difficulty which some of the students had in conceptualizing the operation of subtraction. Five students, in particular, struggled with the idea of taking eight away from certain numbers. Taback felt that the teacher in that situation was not teaching the children at their own levels. Instead, adult standards were being placed upon them, and they became justifiably more frustrated by the teacher's interactions. The ability to understand the thought processes of a student is difficult; however, teachers have the responsibilitty to identify the sources of confusion as well as the areas of strengths for each child.

Influence of School Guidance Counselors

School guidance counselors have the potential to influence students' attitudes toward careers in mathematics and science. To date, however, minority graduates who have undertaken occupations in these fields give relatively little credit to guidance counselors for assisting them. In a study conducted

by Carey (1977), Black engineers were asked to cite the people most responsible for getting them into the field of engineering. The results were as follows: 32% were influenced most be a relative, 26% by either a friend or high school course, 26% were most influenced by a job experience or by the media, and 14% named a teacher or a guidance counselor. Nicholas (1978) felt that counselors need more information about the opportunities that exist for minority students in mathematics and sciences; they should be prepared to discuss the appropriate steps leading to the achievement of vocational goals in these fields. Nicholas also discussed the lack of achievement motivation of minority students in the elementary school. He suggested that vocational counseling in conjunction with self-concept development in the early years may provide incentives for learning. Washington (1976) outlined a motivation process which accented personnal strengths as a possible plan for helping urban adolescents to develop more positive self-concept.

In Carey's (1977) study of the engineering program at Oklahoma State University, he emphasized the importance of ongoing counseling at the college level. Communication with students' high school counselors and the use of Black college graduates to work with faculty and students to increase the retention rate proved invaluable. Both Carey and Crain (1978) mentioned that Black counselors had an added influence on the attendance and survival of Black students in college. Crain surmised that a Black counselor provides a subtle indication of a Black student's academic potential. In this society where professional role models for Blacks are tremendously more disportionate

than the number of White professionals, one can understand the impact of Crain's observations. Scott (1977) found that students ranked the teachers as the strongest school related person influential in their career decisions. For this reason he suggested that more science and mathematics teachers assume career counselor roles when working with minority students.

Just as personal characteristics and experiences have hindered the progress of Black, Hispanic, and Native Americans in mathematics and science, such school related variables as student placement in mathematics, teacher attitude and expectation, and guidance counselor input have also contributed to the present situation.

SECTION V. Summary

This report addressed the problems of underachievement and nonparticipation of Black, Hispanic, and Native Americans in the field of mathematics. The data confirms the existence of a continuous gap between the performance of students from these ethnic groups and that of White students; the results of the second National Assessment of Mathematics Progress indicates a slight narrowing of this gap for the nine-year-old and thirteen-year-old populations. Although the NAEP studies did not include a Native American sample, other sources verify that similar disparities exist; moreover, as the Native American students proceed through our education system, the gap in mathematics achievement between them and White students widens significantly more so than with the other two groups. Of the bachelor's degrees awarded in mathematics in 1976, a mere 7% went to the combined group of Black, Hispanic, and Native Americans.

The learning styles, personality traits, and self-concept levels of minority students were shown to have possible bearing on their mathematics achievement and participation. Some students prefer to utilize the right hemisphere of the brain more than the left hemisphere. These students tend to be at a disadvantage in the classroom, since most activities in our schools favor left hemispheric facility. There is some indication that minority and poor children prefer right hemispheric tasks. The field dependence or field independence of a student also has some bearing on his/her mathematics achievement. Field dependent children need more direction and structure in

the classroom; rarely do field dependent children choose "individual" occupations, such as mathematicians or scientists. Instead, they excell in social science areas and in "people" occupations. The setting of career goals, amount of determination in reaching their stated goals, and feeling of personal control over one's future has much to do with the self-concept of the learner. Students from low income and minority families often exhibit little confidence in themselves and thus set correspondingly low standards for their personal achievement and career objectives.

Children who must cope with more than one language deserve special attention; the linguistic influences on their mathematics learning have been shown to be positive or negative depending on the educational context. Testing of preschool Hispanic students shows no differences in mathematics ability between their performance and that of non-Hispanic students. As the Hispanic child progresses through school, especially after age eight, a significant gap appears and tends to widen in the upper grades. At least one Spanish version of a standardized intelligence test has been shown to accurately predict the achievement of Hispanics; the quantitative and performance scores are the most reliable. Because of their ability to handle two language systems at once, Hispanic children are forced to conceptualize and to think more abstractly than other children. However, more attention must be given to the operation of bilingual programs in our schools; all such programs, assimilationist, pluralistic, or separatist, should utilize the strengths of Hispanic students to improve their mathematics education.

This report discussed some of the effects of school on the mathematics achievement of minority group children. It was found that the direct effect of school variables on mathematics achievement was greater than that of home and environmental variables. Teachers' expectations of minority students' performance in mathematics continue to affect their progress. Their expectations of and attitudes towards students have been shown to be influenced by such nonacademic elements as socio-economic class, verbal facility, physical appearance, and behavior. Many teachers emphasize only the basic operational skills in classes of largely minority enrollment. Tracking by ability in the mathematics area, and the assignment of less experienced teachers to the lower tracks, further debilitate the self-concept and achievement of minority students in our schools. Many guidance counselors fail to encourage members of Black, Hispanic, and Native American students to enroll in higher level mathematics courses or to set occupational goals in the mathematics and science fields. Mathematics and science teachers could have a more positive effect on the career orientation if they were to assume a counseling role with Black, Hispanic, and Native American students. In the next section, recommendations for changes in the educational system are presented. Additionally, suggestions of topics which need further research in the area of minority students' mathematics learning are included.

SECTION VI. Recommendations

Recommendations for Educational Practices

The research reviewed in this report indicate that the following suggestions for reform of educational practices be given full consideration. It is recommended that:

- Educators become aware of the hemispheric dominance of Black, Hispanic, and Native American children and adapt mathematics instruction accordingly.
- Educators become aware of the field dependence or field independence of minority children and adapt mathematics instruction and classroom environment accordingly.
- Appropriate role models in the field of mathematics and science be available to minority students, preferably as teachers or curriculum designers.
- Consideration be given to the interest value of topics in mathematics presented to minority students.
- Educators utilize the strengths of bilingual students so that bilingualism will have a positive effect on intelligence and achievement.
- Educators use the nonverbal ability of bilingual students to enhance their mathematics learning.
- Educators use appropriate standardized tests to measure intelligence of minority students, especially Hispanic students.

- A reevaluation of the system of tracking by ability be undertaken as well as the distribution of teachers to the various tracks.
- Educators insist on incorporating high level cognitive processes in all mathematics classes so as to facilitate upward movement from class to class.
- Educators set higher standards and expectations for Black, Hispanic, and Native American students.
- Mathematics teachers take more responsibility for encouraging minority students to seek careers in mathematics and science.
- Educators investigate the teachability of skills ordinarily acquired outside of school which would improve test scores of minority students.
- Guidance counselors develop programs to build up the self-concept of Black, Hispanic, and Native American students especially those from low income families.
- Teachers of bilingual students are highly fluent and proficient in Spanish.
- Educators be aware of the type of bilingual program in operation in their system, assimilation, pluralistic, or separatist and be aware of its effect on the mathematics achievement of bilingual students.

- Educators assess their interactions with minority students in terms of reinforcement patterns and approvals and disapprovals of work and behaviors.

Recommendations for Further Research

In order to capture a full picture of the mathematics learning of Black, Hispanic, and Native American children, it is essential that further research include these elements which were not addressed in this report:

- Influences of parents, peers, and home environment;
- Effects of socio-economic status;
- Teacher preparation and attitude towards mathematics;
- Effects of desegregation programs and the effects of special remedial programs in mathematics.

In addition, inconsistencies in past research and unavailability of data on certain factors studied which affect the mathematics learning of minority children indicate a pressing need for further research. The following topics need more thorough investigation.

- Effects of race and socio-economic status on the hemispheric dominance of individuals.
- Effects of race and socio-economic status on field dependence.
- Relationship between locus of control and mathematics achievement of Black, Hispanic, and Native American students.

- Learning styles of Native Americans and how they affect their mathematics learning.
- Influences on minority student aspirations and career plans.
- Effects of language and linguistics on the mathematics achievement of Native Americans.
- Influence of race of teacher on mathematics achievement of Black, Hispanic, and Native American students.
- Psychological effects of tracking by ability in mathematics on Black, Hispanic, and Native American students.
- Relative effects of homogeneous and heterogeneous grouping on the mathematics learning of Black, Hispanic, and Native American students.
- Relative effects of the three types of bilingual programs: assimilationist, pluralistic, separatist on the mathematics achievement of Hispanic and Native American children.

The preceding report also indicates certain development needs which, if met, would make the implementation of changes in mathematics instruction easier. These concerns are:

- Specification of those tasks on intelligence and mathematics achievement tests which result in significant racial differences.

- Investigation of interest areas of Black, Hispanic, and Native American children which could be incorporated into a mathematics curriculum.
- Identification of activities which are geared more specifically to right or left hemispheric processing.
- Development of effective means for bilingualism to have a positive influence on mathematics achievement at all economic levels.

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APPENDIX A

Additional References on Other Factors Relevant To Mathematics Learning of Minority Students

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Bridgeman, Brent and Buttram, Joan. "Race Difference on Nonverbal Analogy Test Performance as a Function of Verbal Strategy Training," Journal of Educational Psychology 67, 4 (1975):586-590.

Independent Variable:	Use of verbal strategy training
Dependent Variable:	Performance on nonverbal analogy test
Population:	200 4th and 5th grade students, Black and White.
Outcome:	- There were no significant race differences in performance among those who received special strategy training. - Significant race differences did result in group which received no training.

Buriel, Raymond. "Relationship of Three Field Dependence Measures to the Reading and Math Achievement of Anglo-American and Mexican-American Children," Journal of Educational Psychology 70, 2 (April 1978):167-174.

Independent Variable:	Field dependence, culture; White, Mexican-American
Dependent Variable:	Achievement
Population:	80 students (grades 1-4); 40 Mexican-Americans 40 White Students all attended semi-rural elementary school in Southern California.
Outcomes:	- Field dependence is of substantial importance to achievement of both cultural groups. - Mexican-American students were not more field dependent than White. - Correlations among three field dependence tests used were comparable for both groups.

Byalick, Robert and Bersoff, Donald N. "Reinforcement Practices of Black and White Teachers in Integrated Classrooms," Journal of Educational Psychology 66, 4 (1974):473-480.

Independent Variable:	Teachers in integrated classrooms
	Race of teachers
Dependent Variable:	Use of positive reinforcement
	Preference for type of reinforcement
Population:	30 Black, 30 White teachers and their elementary school classes.
Outcome:	- Reinforcement emission was at consistently low rate.
	- Only 32% of teachers used prefered reinforcement.
	- Black and White teachers had equal rates and types of reinforcement.
	- Teachers intended slightly to reinforce opposite race but more affection was shown within same teacher-student race.
	- Black females were least reinforced group of all.

Colclough, Glenna S. and Lilley, Stephen C. Perceived Blockages in the Occupational Attainment of Southern Black Youth. Paper presented at the annual meeting of the Rural Sociological Society, 1978. Sociological Abstracts no. 78509051. South Carolina: Clemson University.

Independent Variable:	Type of blockage, aspiration level, sex.
Dependent Variable:	Attainment of occupational goals
Population:	1252 Black high school students
Outcome:	- Structural blockages (elements of social and economic system) were most dominant in restriction of goal attainment.
	- Sex had negligible effect on perceptions.

- Individual blockages (personal traits and experiences) had more effect on low aspiring students than on high-aspiring students.

- Structural constraints must be included in programs to raise aspiration levels of Black youth.

Cooper, Harris M.; Baron, Reuben M.; Lowe, Charles A. "Pygmalion Grows Up: A Model for Teacher Expectation, Communication and Performance Influence," Review of Educational Research 49, 3 (Summer 1979):389-410.

Independent Variable:	Race: Black, White; social class: lower-class, middle class.
Dependent Variable:	Expectations about academic performance.
Population:	"Stimulus" student profiles considered by 64 elementary education majors. 64 introductory psychology students.
Outcome:	- Middle class students were expected to receive higher grades. - White middle class students were more internally responsible for academic success and failure. - Elementary education students predicted higher grades than psychology students. - Elementary and psychology students differed on importance of quality of instruction.

Coppus, Sally. "An Investigation Into Computer Programming as an Academic Discipline Which Provides Education for Both Sides of the Brain," Dissertation Abstracts International, 39, (3), 1395A. Doctoral dissertation, University of Massachusetts, 1978. University of Michigan microfilm no. 78-16249.

Independent Variable:	Hemispheric dominance.
Dependent Variable:	Performance in computer programming course.

Population: Ten students from an Upward Bound (high school) Program in Massachusetts, categorized as "right", "left", or "mixed" brain oriented.

Outcome: "Left" oriented students were higher achievers and had more positive attitudes toward computer programming than "right" oriented students.

- "Right" oriented students showed greater ability in thinking of problem as a whole and preferred pictures, words, and poems.
- "Left" oriented students were more tolerant of the step-by-step procedures used.
- All students were actively involved and opened up by using the computer interactively.

Cossio, Maria Jesus Garcia. "The Effects of Language on Mathematics Placement Scores in Metropolitan Colleges," Dissertation Abstracts International, 1977, 38 (7) 4002A. Doctoral dissertation, Columbia Teachers College, 1977. University of Michigan microfilm no. 77-27882.

Independent Variable: Version of placement test: Spanish, English.

Dependent Variable: Performance on mathematics placement test.

Population: 177 Hispanic students from 3 metropolitan New York Colleges - divided according to language proficiency: 1) Basic, 2) Intermediate, 3) Bilingual.

Outcome:

- Basic and Intermediate groups scored better on Spanish version.
- Bilingual group scored better on English version.
- Positive relationship between mathematics performance and second language ability.

Crain, Robert L. and Mahard, Rita E. The Influence of High School Racial Composition on Black College Attendance and Test Performance. Washington, D.C.: National Center for Educational Statistics, U.S. Government Printing Office, 1978.

Independent Variable:	Racial composition: high school, college
	Area of residence in U.S.
Dependent Variable:	Black college attendance, test performance.
	23,451 high school seniors from 1,318 high schools followed for three years.
Outcome:	- Alumni of predominately White schools have 3:2 advantage over alumni of Black schools in rates of becoming college juniors three years after high school (North).
	- Reverse of above is true in the South.
	- The lower the proportion of Black teachers in the school, the lower the grades of Black students and the lower their college attendance rates.
	- Black students in predominately White high schools benefited more in regarded to college opportunities if they had a Black counselor.
	- In the North, Black students from predominately White schools were higher achievers.
	- In the South there was no significant difference in achievement between Black high school alumni and predominately White high school alumni.

Cummins, James. "Linguistic Interdependence and the Educational Development of Bilingual Children," Review of Educational Research 49, 2 (Spring 1978):222-251.

Independent Variable:	Development of first language skills.
Dependent Variable:	Effective bilingual program.

Population: Students involved in several studies of bilingual program effectiveness.

Outcome:
- Development of second language depends on competence in first language.
- Background, child input, and educational treatment factors must be carefully incorporated in order to provide for maximum development of bilingualism.
- Future research must determine which input and process variables are most important.

Denker, Elenor Rubin. Teaching Numeric Concepts to Spanish-Speaking Second Graders: English or Spanish Instruction? Paper presented at the annual meeting of the American Educational Research Association, New York, April 1977.

Independent Variable: Type of instruction - English, Spanish.

Dependent Variable: Performance on numeric concepts test.

Population: 20 non-English speaking second graders; 20 English-speaking second graders.

Outcome:
- Spanish instructed group performed just as well as English instructed group.
- There was a higher correlation between performance scores and mathematics ability in Spanish group than in English group.
- There was a higher correlation between performance success and English ability than with math ability in the English group.

Doebler, Leland K. "A Study of the Effects of Teacher Awareness of the Educational Implications of Field Dependence/Field Independence on Selected Classroom Variables," Dissertation Abstracts International, 1977, 38, (7) 4040A. Doctoral dissertation, University of Mississippi, 1977. University of Michigan microfilm no. 77-28957).

Independent Variable: Teacher awareness of significance of field dependent/field independent cognitive styles.

Dependent Variable:	Students' attitudes toward school, self-concept, teacher ratings of over behavior.
Population:	182 fifth grade students and their teachers in three northern Mississippi public schools.
Outcome:	- Matching students and teachers by cognitive style is not necessary. - Teacher awareness of student's cognitive style has positive effect on learning atmosphere of classroom.

Ebmeier, Howard H. "An Investigation of the Interactive Effects Among Student Types, Teacher Types, and Treatment Types on the Mathematics Achievement of 4th Grade Students," Dissertation Abstract International, 1978, 39 (10) 5932A. Doctoral dissertation, University of Missouri, 1978. University of Michigan microfilm no. 79-06869.

Independent Variable:	Student learning style (field dependent, field independent), teacher type, classroom setting (open/traditional).
Dependent Variable:	Mathematics achievement.
Population:	4th grade students.
Outcome:	Low achievers and field dependent students need more structure and direction than others.

Fisher, Maurice D., et al. "Effects of Student Control and Choice on Engagement in a CAI Arithmetic Task in a Low-Income School," Journal of Educational Psychology 57, 6 (December 1975):776-783.

Independent Variable:	Amount of choice and control.
Dependent Variable:	Task engagement.
Population:	38 fourth and fifth graders in low income schools.
Outcome:	- Choice students showed more engagement in Computer Assisted Instruction (CAI) tasks than no-choice students.

- Engagement was highest for easiest problems and lowest for most difficult.

- No-choice students had higher achievement scores.

Gardner, Howard; Strub, Richard; Albert, Martin L. "A Unimodal Deficit in Open Thinking," Brain and Language 2, 3 (July 1975):333-344.

Independent Variable: Functioing of left hemisphere of brain.

Dependent Variable: Mathematics ability.

Population: A forty-one year old man who had recently suffered a left hemisphere stroke.

Outcome:

- Inability to understand meaning of numerical terms related to stroke.

- Inability to perform mathematics and logical operations when auditory oral procedures were used and was also related to malfunctioning of left hemisphere.

Glantz, Oscar. "Locus of Control and Aspirations to Traditionally Open and Traditionally Closed Occupations," Journal of Negro Education 46, 3 (1977):278-290.

Independent Variable: Locus of control.

Dependent Variable: Competitive risk-taking in selecting occupation.

Population: 141 American-born Blacks; 59 West-Indian Blacks.

Outcomes:

- There was a high correlation between high internal locus of control and risk-taking among American-born Blacks.

- Locus of control was a neutral factor in West-Indian-born Blacks' choices of occupation.

Gordon, Bobby Will. "A Profile of High and Low Achievers in Mathematics Among Selected 6th Graders," Dissertation Abstracts International, 1977, 38 (8), 4639A. Doctoral dissertation, Duke University, 1977. University of Michigan microfilm no. 77-31667.

Independent Variables:	Quantitative intelligence, ability to conserve, reading level, parents' vocational status, attitude towards mathematics, self-concept, sex, race.
Dependent Variable:	Achievement in mathematics.
Population:	174 students - sixth graders from the Southern School Zone in Alamanac County, North Carolina.
Outcome:	- Quantitative I.Q. is related to achievement in mathematics. - Ability to conserve enhances students' chances of success in mathematics. - Achievement is related to self-image and image of peers, teachers, school. - Reading and vocabulary are positively related to mathematics achievement. - Vocational status of parents also is related to mathematics achievement.

Gulliner, Markita L. "The Effect of Spatial Visualization Factor on Achievement on Operations with Fractions," Dissertation Abstracts International, 1979, 39 (9) 5381A. Doctoral dissertation, University of Minnesota, 1978. University of Michigan microfilm no. 79-06321.

Independent Variable:	Spatial visualization ability.
Dependent Variable:	Achievement on fractions operations.
Population;	320 fourth graders.
Outcome:	Spatial visualization ability was related to achievement on fractions test.

Heimbuch, Bonnie Lee Aufenkamp. "Cognitive Preferences in Mathematics of Elementary Teachers: Identification and Relationships," Dissertation Abstracts International, 1977, 38 (5) 2628A. Doctoral Dissertation, University of Texas, 1977. University of Michigan microfilm no. 77-22965.

Independent Variable:	Teacher type: elementary, pre-service, non-teacher aspiring college students.
Dependent Variable:	Choice of cognitive process in mathematics
Population:	233 subjects.
Outcome:	- Inservice and preservice teachers preferred memory and application over generalization. - Non-teaching aspiring college students chose generalization over the other two processes. - Preferences were related to academic preparation in mathematics.

Heller, Marc S. and White, Mary A. "Rates of Teacher Verbal Approval and Disapproval to Higher and Lower Ability Classes," Journal of Educational Psychology 67, 6 (1975):796-800.

Independent Variable:	Ability level of class: high, low.
Dependent Variable:	Rate of verbal approval and disapproval.
Population:	10 junior high school teachers and their classes in an inner-city public school in New York City.
Outcome:	- Teachers emitted more disapprovals in lower ability classes than in higher ability classes, especially regarding social behavior. - Teachers almost never praised pupils for behaving well socially but did approve of instructional behaviors overall more than they disapproved of them.

Horak, Virginia Witt. "Effects of Inductive-Deductive Teaching Methods and Field Dependent-Independent Cognitive Styles Upon Student Achievement," Dissertation Abstracts International, 1978, 39 (1), 169A. Doctoral dissertation, University of Iowa, 1977. University of Michigan microfilm no. 78-10352.

Independent Variable:	Style of teaching-deductive, inductive.
Dependent Variable:	Achievement in mathematics.
	Field dependence.
Population:	118 preservice elementary school teachers.
Outcome:	- Inductive teaching was better for producing transfer of learning to new situations.
	- Field dependent students should always be taught by inductive methods.

Kagan, Spencer and Zahn, G. Lawrence. "Field Dependence and the School Achievement Gap Between Anglo-American and Mexican-American children," Journal of Educational Psychology 67, 5 (1975):643-650.

Independent Variable:	Field dependence, culture: White, Mexican-American.
Dependent Variable:	Reading and mathematics achievement.
Population:	134 2nd, 4th and 6th graders from lower income elementary school in Southern California.
Outcome:	- Mexican-Americans who were more field dependent had more difficulty in reading than in mathematics.
	- Field independence is significantly related to math and reading achievement.
	- Cultural background has a more direct impact in reading than in mathematics.

Kemp, Judy Beth. "An Investigation of the Effects of Varying Left and Right Hemisphere Activities on the Achievement of 5th Grade Science Students," Dissertation Abstracts International, 1979, 39 (9), 5430A. Doctoral dissertation, University of Southern Mississippi, 1978. University of Michigan microfilm no. 79-05130.

Independent Variable:	Type of activity (right hemisphere, left hemisphere, mixed orientation).
Dependent Variable:	Achievement in science.
Population:	130 fifth graders.
Outcome:	No significant difference in achievement when all types were presented to all students.

Kennedy, Mary L. "Young Children's Use of Written Symbolism to Solve Simple Verbal Addition and Subtraction Problems," Journal of Children's Mathematics Behavior 1, 4 (Spring 1977):122-134.

Independent Variable:	Ability to write mathematics symbols.
Dependent Variable:	Mathematics understanding.
Population:	One preschool class and two kindergarten classes.
Outcome:	- Ability to write was no indication of understanding of mathematics concepts.

Lanier, James and Wittmer, Joseph. "Teacher Prejudice in Referral of Students to EMR Programs," School Counselor 24, 3 (January 1977):165-170.

Independent Variable:	Race of student: Black, White.
Dependent Variable:	Referral to Educable Mentally Retarded classes.
Population:	359 elementary school teachers.
Outcome:	- Black students were more frequently referred to ERM classes than White students. - Teachers were more likely to confer with White parents than with Black parents.

Meissner, Judith A. "Use of Relational Concepts of Inner-City Students," Journal of Educational Psychology 67, 1 (1975):22-29.

Independent Variable:	Age, race
Dependent Variable:	Communication of concepts, comprehension of concepts.
Population:	54 2nd grade Black children; 38 4th grade Black children. Both groups attended school in South Bronx of New York City.
Outcome:	- Comprehension was significantly easier than communication for Black children. - Fourth graders were much better at communication than second graders. - Fourth graders used previous comprehension to communicate more effectively.

Moses, Barbara Elaine. "The Nature of Spatial Ability and Its Relationship to Mathematics Problem Solving," Dissertation Abstracts International, 1977, 38 (8), 4640A. Doctoral dissertation, Indiana University, 1977. University of Michigan microfilm no. 77-30309.

Independent Variable:	Instruction in geometric technique (Part A) Spatial ability (Part B)
Dependent Variable:	Spatial ability (Part A) Problem solving performance (Part B)
Population:	145 students - four 5th grade classes from Newburgh, Indiana.
Outcome:	Part A: Instruction had a strong positive effect on spatial ability but much less influence on level of visuality in problem solving. Part B: Spatial ability was positively correlated with problem solving performance.

Mullis, Ina Van Slyke. "Effects of Home and School on Learning Mathematics and Political Knowledge and Attitude," Dissertation Abstracts International, 1979, 39 (8), 4839A. Doctoral dissertation, University of Colorado at Boulder, 1978. University of Michigan microfilm no. 79-03076.

Independent Variable:	Home environment, school-related variables.
Dependent Variable:	Mathematics learning, political knowledge, attitude.
Population:	For mathematics investigation: 10,000 17-year-olds used in N.A.E.P. testing program.
Outcome:	- In mathematics the direct effect of school is greater than the direct effect of home. - Total effect of home (including effects of home implemented through school) was slightly greater than direct effect of school. - Most important school variable was exposure to subject matter.

Phipps, Dorri Lenora. "Effects of Placing Traditionally Educated Urban 6th Graders With Selected Learning Styles in Open and Traditional Classroom Environments," Dissertation Abstracts International, 1977, 38 (4), 1961A. Doctoral dissertation, Temple University, 1977. University of Michigan microfilm no. 77-21783.

Independent Variable:	Classroom environment, field dependence.
Dependent Variable:	Achievement.
Population:	140 6th graders who had been traditionally educated.
Outcome:	- Field independent students performed well in both environments - open and traditional. - Field dependent students performed better in the traditional classroom.

Schoen, Harold L. "Self-Paced Mathematics Instruction: How Effective Has It Been in Secondary and Post-Secondary Schools?" The Mathematics Teacher 69, 5 (May 1976):352-357.

Independent Variable:	Type of instruction: self-paced, traditional, guided discovery.
Dependent Variable:	Mathematics achievement.
Population:	Students involved in 50 studies comparing instruction types.
Outcome:	- Improvement in mathematics did not occur with self-paced method; there was decreased performance in 5th-8th grade classes. - Affective measures improved in K-4 with individualized approach. - Individualized approach was most expensive and time consuming method for the teachers.

Shellenberger, Sylvia. "A Cross-Cultural Investigation of the Validity of the Spanish Version of the McCarthy Scales of Children's Abilities for Puerto Rican Children," Dissertation Abstracts International, 1977, 38 (8), 4698A. Doctoral dissertation, University of Georgia, 1977. University of Michigan microfilm no. 77-30509.

Independent Variables:	Culture, place of residence, subtests of McCarthy Scales.
Dependent Variable:	Validity of McCarthy Scales.
Population:	50 Puerto Ricans in Puerto Rico; 50 Puerto Ricans in Pennsylvania.
Outcome:	- Quantitative and performance scales were best predictors of total achievement. - U.S. Puerto Ricans had greater gap in verbal area than Native Puerto Ricans. - Quantitative tasks seemed to parallel skills taught in school more so than verbal tasks. - McCarthy Scales were found to be less culture biased than other standardized intelligence tests.